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Improving Highway Information at Hazardous Locations

Seven Case Studies—Summary of Demonstration Project No. 48

March 1985

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of Demonstration Project No. 48

Final Report
March 1985

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ABSTRACT

This report summarizes the results of Demonstration Project No. 48 - Application of the Positive Guidance Process. The Positive Guidance process is designed to analyze a hazardous location's safety and/or operational problems and develop low-cost, short-range information system solutions. The demonstration project was begun in 1978 and completed in 1984. Its objectives were to: (1) Apply Positive Guidance to a range of situations; (2) Demonstrate its effectiveness; (3) Improve the safety and/or operations of the sites; and (4) Provide inputs to upgrade the Users' Guide to Positive Guidance (1st Edition). A total of $625,000 was allocated for seven projects in Washington (2 projects), Michigan, New Jersey, Georgia, California, and Iowa.

Five of the seven projects were fully successful in achieving the objectives, and the remainder were partially successful. Information and feedback from the projects was used to develop the 2nd Edition of the Users' Guide to Positive Guidance. It was demonstrated that Positive Guidance was applicable to locations requiring short-range low-cost information system solutions to safety and/or operational problems.

INTRODUCTION

The purpose of this report is to provide a summary of Demonstration Project No. 48 -- Application of the Positive Guidance Process. Demonstration Project No. 48 was initiated in 1978 to apply the Positive Guidance process at a number of problem sites around the United States, and to show how the process could develop improvements to enable drivers to negotiate these locations safely and efficiently.

The Positive Guidance concept was developed in 1973 when, as a result of two catastrophic bridge accidents, congressional hearings were held on the narrow bridge problem. It became apparent that because of the great cost, achieving safety at hazardous locations strictly through reconstruction was an unrealistic and probably unattainable goal. Then-Federal Highway Administrator Tiemann concluded that if we could not physically protect motorists at all hazardous locations, "we must give them enough information so that they can protect themselves." The development of that information system concept led to Positive Guidance.

The publication Positive Guidance in Traffic Control (Reference 1) was basically a treatise on the principles involved in the concept and the outline of a systematic procedure for its application. This publication was the beginning of a development program to generate a Users' Guide and to train State and local personnel in the use of the Positive Guidance process. The 1st Edition of the Users' Guide to Positive Guidance (Reference 2) was distributed to engineers throughout the country, and training was provided to over 2,000 State and local

personnel. Following this distribution and training, Demonstration Project No. 48 was established. Feedback and suggestions for improving the process obtained from the demonstration project were used to develop the 2nd Edition of the Users' Guide to Positive Guidance (Reference 3).

THE POSITIVE GUIDANCE PROCESS

Positive Guidance is an approach to enhance the safety and operational efficiency of hazardous or inefficient locations. This approach joins the highway engineering and human factors technologies to produce an information system matched to the characteristics of the location and the attributes of drivers. Positive Guidance is designed to provide high-payoff, short-range solutions to safety and operational problems at relatively low cost. It is based on the premise that a driver can be given sufficient information to avoid accidents and/or drive efficiently at hazardous locations or locations with operational problems.

Since few locations are identical, each must be individually analyzed to develop appropriate improvements. Positive Guidance is a tool to both analyze the location, and to develop solutions to problems at the site. The Positive Guidance process, as set forth in the 1st Edition of the Users Guide to Positive Guidance (Reference 2) is shown in Figure 1. It consists of six major functions and eighteen activities. The first three functions are data collection at problem locations, problem specification, and definition of performance factors. These serve as tools to define the nature of the problems at the location. The next two functions define information system requirements and determine Positive Guidance information. The output of these activities aids in the design of information system improvements. The final function is an evaluation of the improvement.

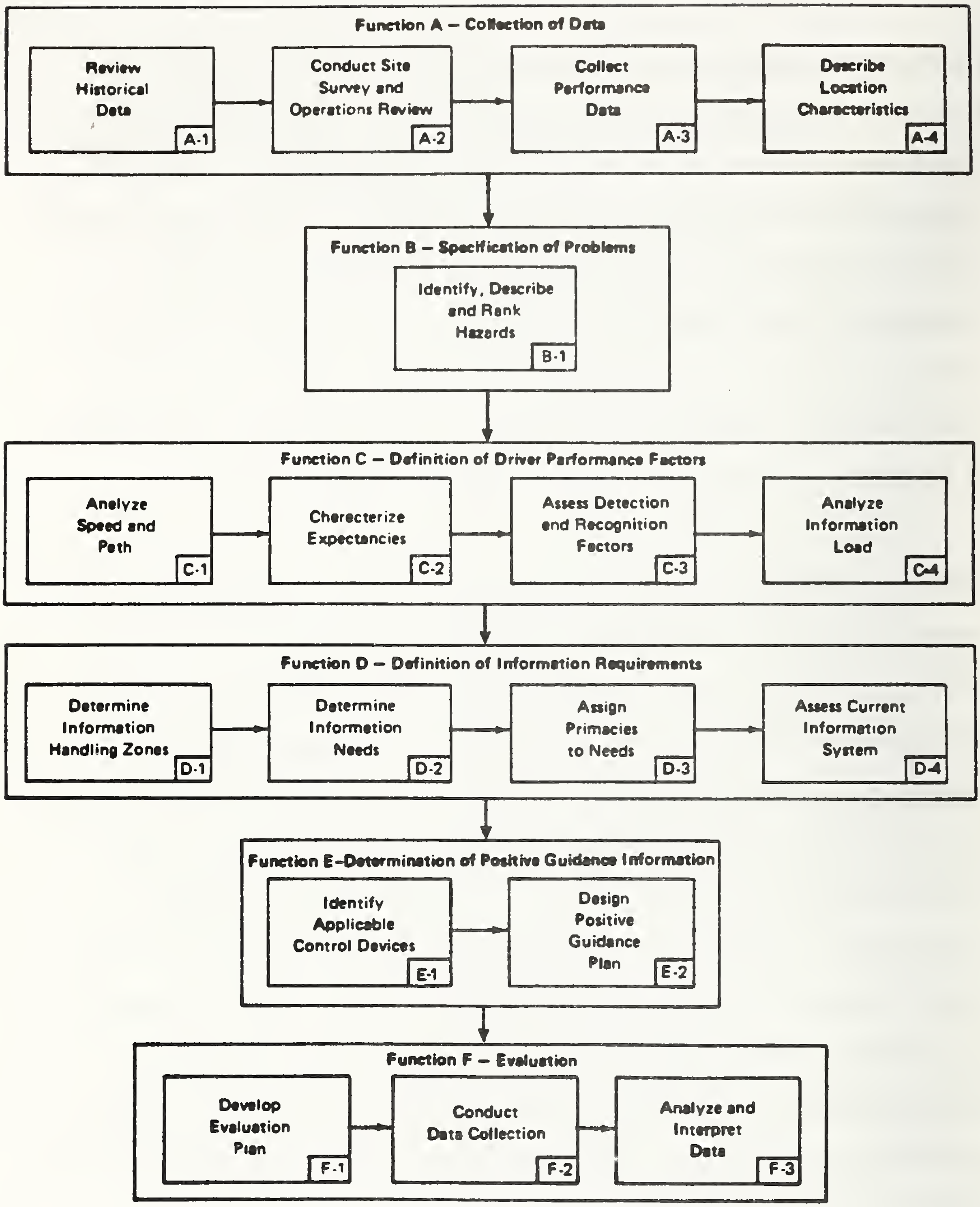

Figure 1. The Positive Guidance Process -- 1st Edition Version.

The Positive Guidance process has been upgraded and is presently documented in separate volumes corresponding to the three interrelated phases shown in Figure 2. The three phases are Planning and Field Data Collection (Reference 4), Evaluation of Traffic Operations, Safety and Positive Guidance Projects (Reference 5) and "The Engineering and Human Factors Procedure" contained in the 2nd Edition of the Users' Guide to Positive Guidance (Reference 3).

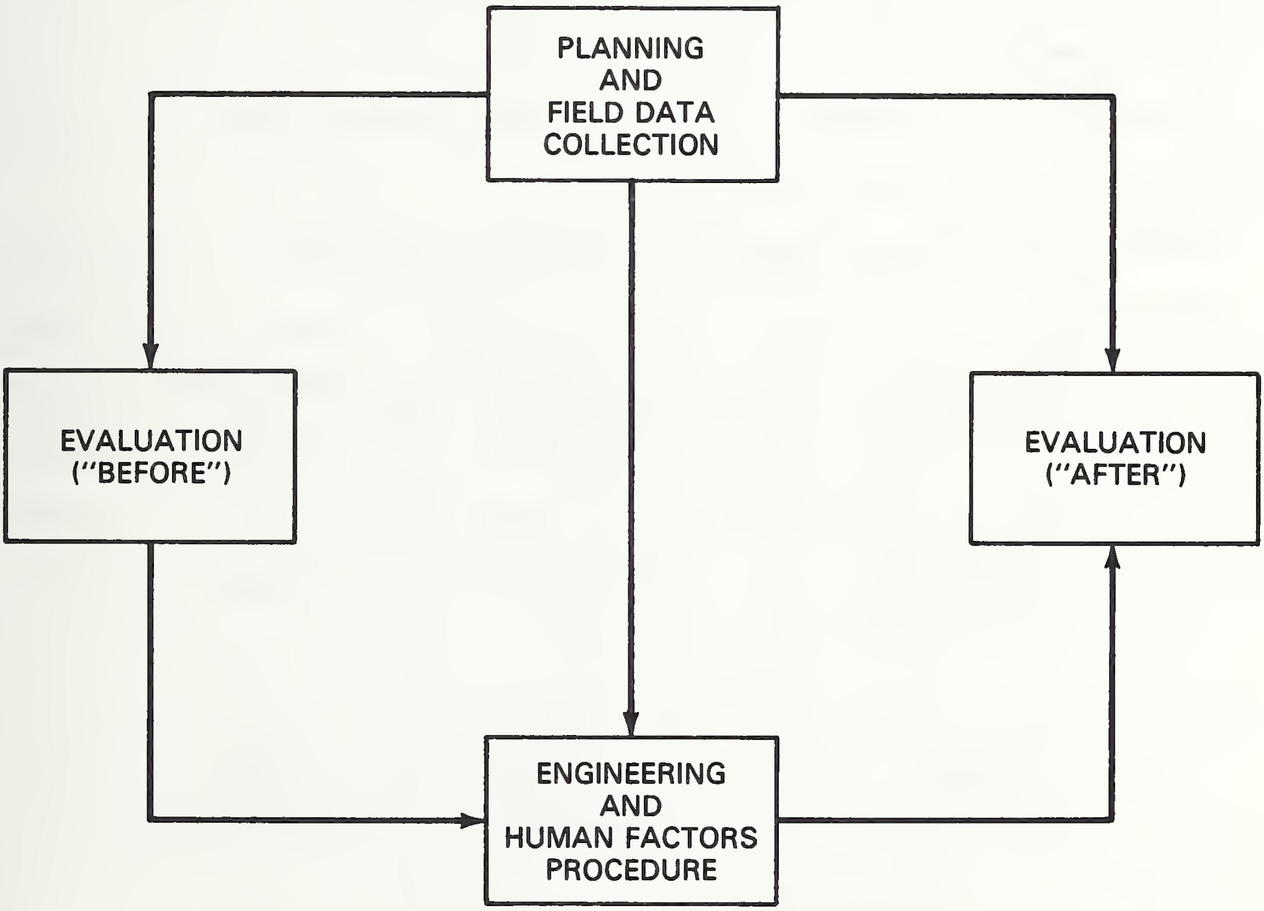

Figure 2. Overview of the Positive Guidance Process -- 2nd Edition Version.

The "Engineering and Human Factors Procedure," the heart of the Positive Guidance process, is shown in Figure 3. It uses data from the Planning and Field Data Collection and Evaluation phases to develop information system improvements. The process has been streamlined to now consist of the following 12 steps: (1) Identify Hazards; (2) Determine Information Handling Zones; (3) Analyze Speed and Paths; (4) Analyze Expectancy Violations; (5) Assess Hazard Detection and Recognition; (6) Perform Information Load Analysis; (7) Determine Information Needs and Assign Primacies; (8) Assess Current Information System; (9) Identify Applicable Traffic Control Devices; (10) Select Devices; (11) Develop Positive Guidance Plan; and (12) Review Design. The first six steps analyze the site's problems. The next two steps identify the information needed by drivers and assess the current information display. The remaining steps design the information system improvements.

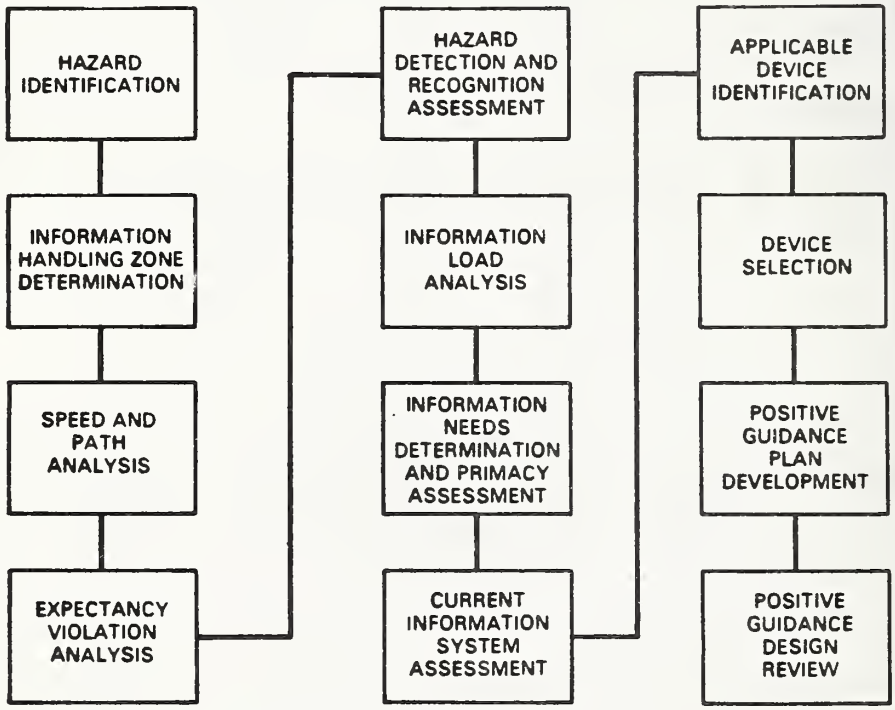

Figure 3. The Engineering and Human Factors Procedure.

BACKGROUND

The Department of Transportation and Related Agencies Appropriations Act of 1978 appropriated $225,000 to the Federal Highway Administration (FHWA) to implement a program demonstrating the Positive Guidance procedure. The program, Demonstration Project No. 48--Application of the Positive Guidance Process was administered by the Demonstration Projects Division, Office of Highway Operations*. Technical management of the program was under the auspices of the Traffic Engineering Division, Office of Traffic Operations. The Demonstration Project was initiated during Fiscal Year 1978 with individual projects in three States--Washington, Michigan, and New Jersey.

Two hundred thousand dollars ($200,000) was appropriated during fiscal year 1979 to continue the program and expand its geographic representation. The Congress indicated an ongoing interest in Positive Guidance and requested that projects be undertaken at locations in the southern tier of the United States. Additional projects were selected in Georgia and California.

In fiscal year 1980, a final allocation of $200,000 was made to apply the Positive Guidance procedure in an urban location. The State of Iowa was selected to administer a project in the City of Dubuque, Iowa.

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*At the time the Demonstration Project was initiated, the Demonstration Projects Division was part of the Eastern Direct Federal Division, Region 15, FHWA, Arlington, Virginia 22201.

A project was added during fiscal year 1982 in Washington to replace one of the original projects that was terminated due to a flood.

SUMMARY OF RESULTS

The objectives of Demonstration Project No. 48 -- Application of the Positive Guidance Process were:

(1) Apply Positive Guidance to a range of situations, highway types, and land uses.

(2) Demonstrate its effectiveness.

(3) Improve the safety and/or operational efficiency of the various demonstration project sites.

(4) Evaluate the process (contained in the 1st Edition of the Users' Guide to Positive Guidance) and make recommendations for improvements.

In total, $625,000 was allocated for Demonstration Project No. 48. Six States participated, with seven sites being fully analyzed, improved and evaluated (two additional sites were partially treated). The sites where Positive Guidance was fully implemented included: Three rural two-lane sites (a reverse-curve/narrow bridge and a winding road in Washington and a railroad-highway grade crossing in Georgia); two urban intersections (a traffic circle in New Jersey and a compound intersection in Iowa); and two freeway interchanges (a split in Michigan and an interchange lane drop in California). The jurisdictions that participated included: two State DOT Central Offices (Michigan and New Jersey); two State DOT District Offices (Washington District 4 and California District 11); a City Engineering Department (City of Dubuque, Iowa); and a university (Georgia Institute of Technology).

Conclusions and Recommendations

- Five of the seven projects fully achieved the objectives.

- Six projects used the 1st Edition of the Users' Guide and one project used the 2nd Edition of the Users' Guide.

- In two projects, problems in implementing the process and/or evaluating the improvements resulted in a partial achievement of the objectives.

- Experience gained in the application of the 1st Edition of the Users' Guide in the first six projects, and inputs from project personnel were used to develop the 2nd Edition of the Users' Guide. A final project applied the 2nd Edition and demonstrated that the primary 1st Edition objection, redundancy, was eliminated.

- The Positive Guidance Process was determined to be applicable to a range of problem locations, highway types, and environments requiring short-term, low-cost information system improvements.

- Engineers and technicians in a range of organizational units were able to apply the process and develop effective improvements to safety and/or operational problems.

- The process was found to be a useful training tool for entry level personnel.

- The 2nd Edition version of the Users' Guide was demonstrated to provide a simpler, easier to apply, less redundant process.

- The Positive Guidance process was shown to be a valuable tool for use by a State or local jurisdiction to improve the safety and operational efficiency of its highway system. It is recommended that the process, tailored to the needs and organizational structure of a particular jurisdiction, as applicable, be incorporated in its improvement program.

SUMMARY OF INDIVIDUAL DEMONSTRATION PROJECTS

On April 4, 1978, the Washington State Department of Transportation, Division of Highways, contracted with the Demonstration Projects Division, FHWA, to apply the Positive Guidance process on two sites in Washington. The contract was to be divided equally between Washington District No. 3 and District No. 4. The District No. 3 project was ultimately terminated prior to improvement implementation due to a flood and bridge washout. A report was issued by District No. 3 and is on file at the Office of Traffic Operations, FHWA, Room 3103C, 400 Seventh Street, SW., Washington, D.C. 20590.

District No. 4 Project Description and History

The District No. 4 site was located at M.P. 21.77 on State Route 6 in Pacific County. The location was approximately 30 miles west of Chehalis, Washington. It was the eastbound approach to a bridge crossing the Burlington Northern railroad tracks (referred to as "Pluvious Westerly"). The roadway approaching the site was a two-way, two-lane road with 12-foot lanes, 8-foot shoulders, slightly uphill and nearly tangent. For the 3 years prior to the project there were eight reported accidents (two multiple collisions) and eight unreported accidents. The site was a low volume (1110 ADT) rural location.

The project was initiated in April of 1978 and completed in September of 1980. The Positive Guidance process was applied to the site in the eastbound direction. "Before" data were collected in the spring and summer of 1978. The Positive Guidance improvements were implemented in

February 1980, and "After" data were collected in the summer of 1980. The delay between data collection periods was due to the Mount St. Helens volcanic eruptions. A final report was submitted in December 1981 and published in 1982 (Reference 6).

Site Assessment ("Before")

The 1st Edition of the Users' Guide was used to assess the site's operations and the suitability of its existing ("Before") information system. Among the determinations made from this assessment was the fact that an earth berm adjacent to the railroad hid the bridge from the driver's view. When the bridge did come into view, a false horizon, created by the alignment of the railroad, made the bridge look like an incidental road. In addition, existing signing and markings (see Figure 4), including a "special" reverse curve warning sign with flashing lights, did not clearly delineate the road's alignment or locate the bridge and bridge approach hazard. Thus, both the nature of the approach, i.e., a compound curve, and the narrow bridge, were not apparent to motorists using the road in the eastbound direction. Speed and path studies showed that drivers were experiencing problems following the road at a proper speed, particularly in the approach to the bridge.

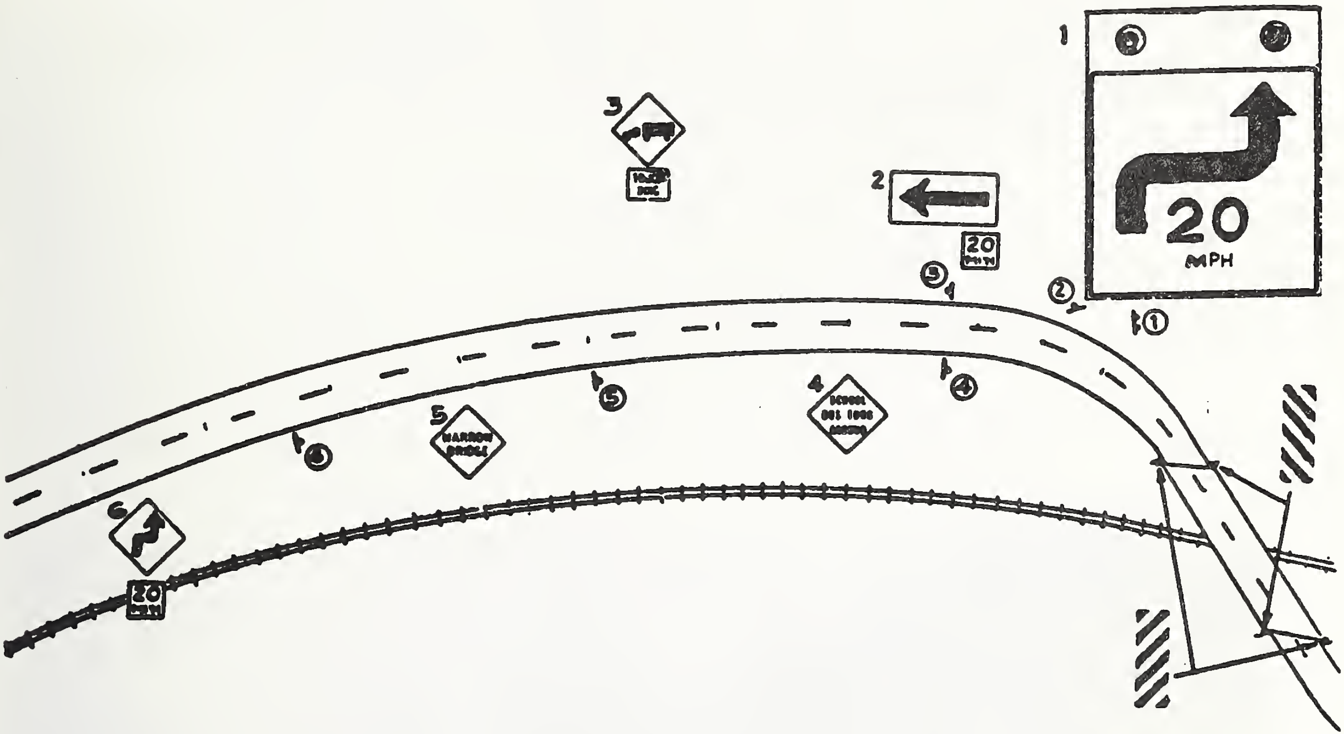


Figure 4. Existing ("Before") Information System.

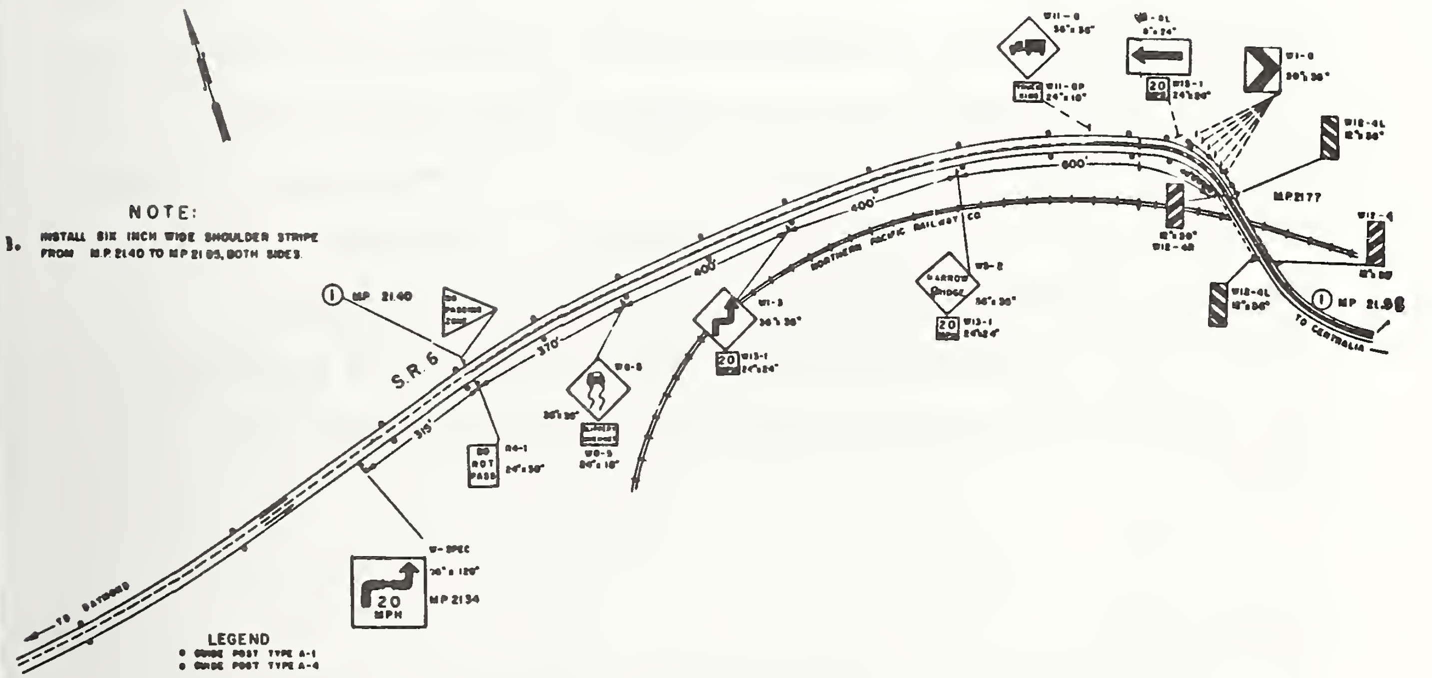
Positive Guidance Plan

Figure 5 shows a view of the eastbound railroad bridge approach with the Positive Guidance improvement in place. The Positive Guidance plan (the plan that contains the information system improvement) that the project team generated in Function E of the 1st Edition is shown in Figure 6. In addition, the earth berm was lowered to enable drivers to see the bridge sooner. Among the features of the plan were enhanced speed control and path delineation in the bridge's approach zone. The 6-inch edge striping, in combination with double yellow center lines and Chevron Alignment signs, served to locate the compound curve bridge approach and

provided an easier path to follow. The new sequence of standard and "special" signs served to warn motorists of the approach and the bridge, and displayed needed speed and path information.

Figure 5. Eastbound Bridge Approach-Positive Guidance Improvement.

Figure 6. Positive Guidance Plan.



Project Evaluation ("After")

After an Implementation and Acclimation Period, a project evaluation phase was performed in accordance with Function F of the Positive Guidance process. A comparison of "Before" and "After" data under fully comparable conditions was difficult, due to the long time period that elapsed and the changed traffic patterns caused by the Mount St. Helens eruptions. However, there were significant improvements in a number of measures of effectiveness (MOE's). Approach speeds were lowered from 51 mph to 40 mph, and speeds at the bridge dropped from 46 to 31 mph (85 percentile speeds). In addition, while it was not possible to do a formal accident analysis due to an incomplete "After" data base, no accidents have taken place 18 months after the improvements were implemented. Finally, an analytical assessment of the changed information system, augmented by engineering judgement, found the driver's task approaching and negotiating the hazard zone to be easier, with less load and an earlier detection and recognition of the site's hazards.

Project Costs

Thirty seven thousand, five hundred dollars ($37,500) was allocated to District No. 4, of which $26,060 was spent as follows:

- Supplies and Materials: $6,945
- Vehicles, Equipment, etc.: $1,348
- Labor: $17,767

Conclusions

In their final report, project personnel concluded that: "The Positive Guidance Process was a beneficial tool both in the determination of a problem and in the development of its correction." The staff followed the Functions contained in the 1st Edition in sequence and felt that there was some redundancy that could be eliminated by combining steps and streamlining the Positive Guidance process. One aspect of the process that was considered of special help was the Information Load Diagram which was found to be an "extremely valuable tool" in determining how drivers respond to the environment and the driving task. In all, the project was considered a success by both the State's project staff and FHWA personnel.

FREEWAY SPLIT: MICHIGAN

Project Description and History

On May 17, 1978, the State of Michigan, State Highway Commission, signed a contract with the Demonstration Projects Division, FHWA, to design, implement, and evaluate a Positive Guidance analysis at a semi-urban freeway location. The site, selected from a number of suggested locations submitted by district traffic and safety engineers, was the eastbound I-96 freeway split at the I-296/U.S. 131 interchange. It was located just northwest of the city of Grand Rapids, in the city of Walker. Interstate Route 96 eastbound was a two-lane roadway that became three lanes with the addition of an entrance ramp from State Route M-37. The three lane section split into two 2-lane roadways about 1,000 feet downstream of the entrance ramp. The 1,000-foot, 3-lane section contained a heavy weaving movement, and the bifurcation area was the scene of numerous erratic maneuvers and conflicts. A major complaint at this site was that the freeway deflected to the left at the bifurcation point while the 2-lane ramp continued straight ahead. The location, in the 3-year period prior to project implementation, experienced 32 accidents. Traffic volume was moderate, with an ADT of approximately 27,000.

The project was initiated in May of 1978 and completed in August of 1980. The Positive Guidance procedure was applied to the eastbound section of I-96 for a distance of approximately 2 miles upstream of the split to the I-96/U.S. 131 junction. "Before" data were collected during the summer and fall of 1978. The improvements were started in

July of 1979, and "After" data were collected in the summer of 1980. A final report was published in 1982 (Reference 7).

Site Assessment ("Before")

The site was assessed using the procedure contained in the 1st Edition of the Users' Guide. The major accident and operational problems at the site were found to occur in the 3-lane weave zone between the M-37 entrance ramp and the freeway split. In this "hazard zone" area, vehicles on the ramp had a difficult time merging into the middle lane. To add to the problem of the short weave zone, motorists had to decide which route and which path to select at the bifurcation. Analysis of the existing information system (See Figures 7 and 8) showed that there was insufficient information displayed in advance to provide drivers with knowledge of what to expect in the weaving section. In-place path (guidance) and route (navigation) information carriers (including a lack of lane markings) were not satisfying driver information needs, and there was a lack of integration among guidance and navigation displays. Thus, the site had both geometric and traffic control device deficiencies.

Positive Guidance Plan

A number of changes were made to the traffic control devices at the site. The primary signing changes were the addition of diagrammatic guide signs at the 1-mile split, and a flashing beacon added to the M-37 on-ramp merge warning sign. Lane markings for the added lane were also added at the on-ramp and carried through to the split. These changes are shown in Figures 7 and 8. This plan informed the driver in advance

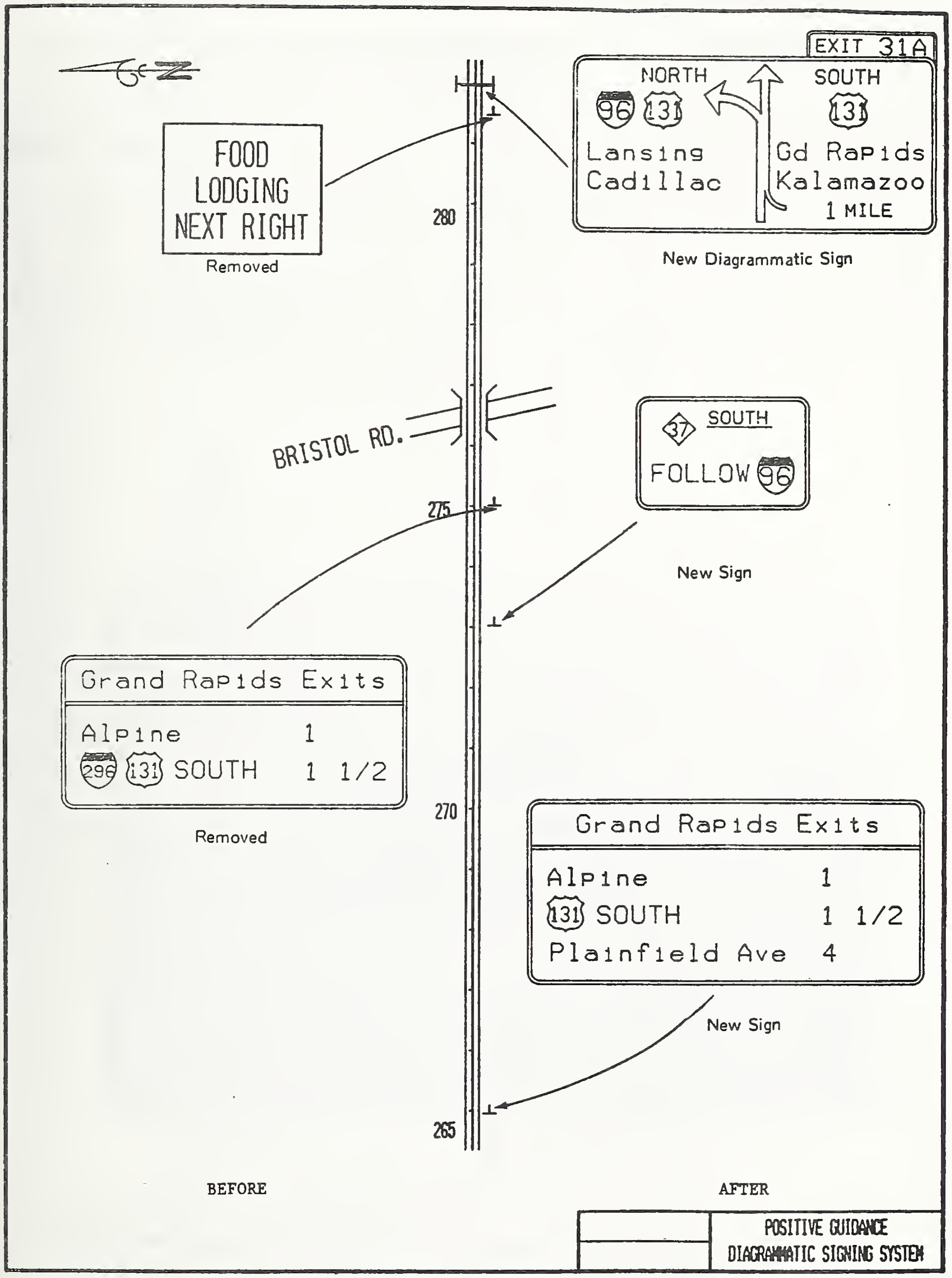


Figure 7. Before and After System.

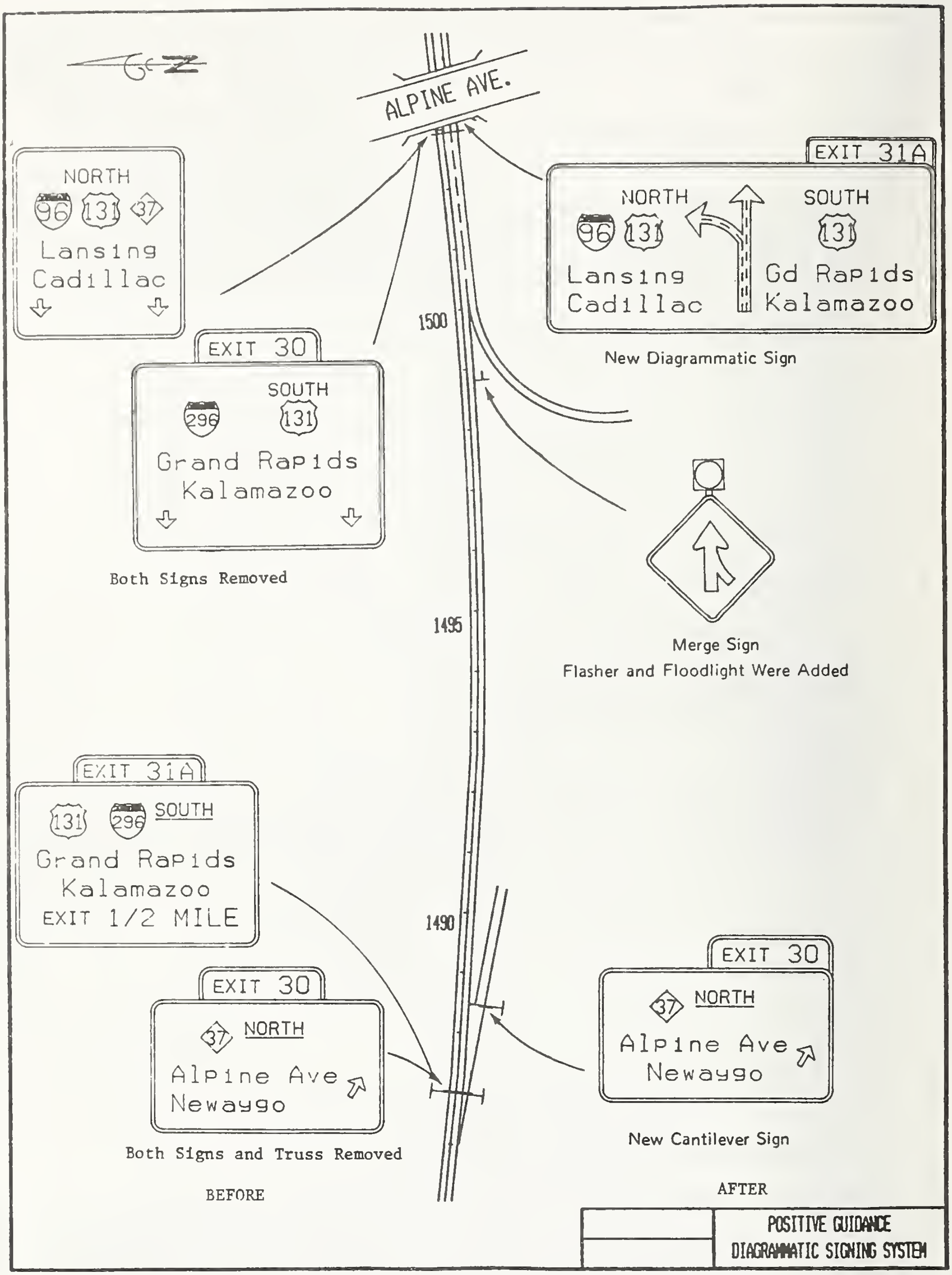


Figure 8. Before and After System.

of the geometric conditions downstream, and provided an integrated information presentation through the display of navigation information. It also provided sufficient information to enable drivers to make needed lane assignment decisions. Figure 9 shows a view of the site at the split after the Positive Guidance improvement was implemented.

Figure 9. Diagrammatic Treatment at Split.

Project Evaluation ("After")

In addition to accidents, the traffic performance measures of effectiveness (MOE's) that were used to evaluate the improvements were erratic maneuvers, brake light applications (as measures of conflicts), lane changes and lane volumes. Data on traffic performance MOE's were collected during weekday AM peak, weekday noon off-peak, and weekend (Sunday) evening periods. Video equipment was used to view and record operations upstream and downstream of the Alpine Avenue Overpass. It was found that both erratic maneuvers and brake light applications were reduced by over 30 percent. This reduction was most evident during the Sunday evening period. The project personnel were unable to draw any conclusions about the apparent lack of change in lane changing and volume data because of possible methodological problems in data collection techniques (i.e., the inability of the technique to capture upstream lane changes). The time frame of the project precluded a formal accident analysis. However, in the "Before" period, the site experienced an average of 10.5 accidents per year, while in the first year and a half of the "After" period, following implementation and acclimation to the changes, the site experienced 7.6 accidents per year, a decrease that appeared encouraging from a safety standpoint.

Project Costs

Although $75,000 was allocated for this project, the final project cost turned out to be $110,000. The additional funding was due to an unexpected $52,400 cost for new overhead sign supports. The remainder of the costs were for labor and materials. The shortfall between the contractual allocation and project costs was made up out of

Interstate Safety funds on a 90/10 basis (Federal/State).

Conclusions

Subsequent accident data from the Michigan Department of Transportation has shown the encouraging accident reduction trend noted during the 1st year after implementation to be holding beyond the second year. Reductions in erratic maneuvers and brake light applications showed an improvement in traffic operations at the split. Since these MOE's are indications of driver directional uncertainty and path confusion, a decrease in conflicts at the weaving section was also observed. This decrease may have contributed to the decrease in accidents after the improvement was applied. As stated by the project engineer:

> The Positive Guidance principles and diagrammatic signs tested here thus appear promising. Further applications may be warranted in other confusing situations or in situations where signs require replacement for maintenance and could, thus, be economically converted to a diagrammatic display.

CUT-THROUGH TRAFFIC CIRCLE: NEW JERSEY

Project Description and History

On May 25, 1978, the New Jersey Department of Transportation contracted with the Demonstration Projects Division, FHWA, to apply Positive Guidance at a hazardous, urban location with an apparent information problem. The project was located in Cherry Hill Township, New Jersey, on State Route (SR) 38 at milepost 3.9. The site was approximately 7 miles from the city of Philadelphia, Pennsylvania. The site selected was the "Route 38-Church Road-Coopertown Traffic Circle." It was a "cut-through" circle with traffic signals at both intersections of the circle with SR 38. The circle was unusual for "typical" New Jersey traffic circles in a number of respects: 1--There was a third, closely spaced signal before the circle in the eastbound direction at the stop line for a fire house; 2--the major route, SR 38, went straight through, rather than around the circle and; 3--the circle was "six-legged." There were also a number of commercial establishments adjacent to and within the circle itself and along its various legs. The site experienced 137 accidents in the 3-year period prior to project initiation. Traffic volume was moderate-to-heavy, with an ADT of approximately 20,000. The site was a commuter route to the Camden-Philadelphia area with distinct AM peaks in the westbound direction and PM peaks in the eastbound direction.

The project began in June of 1978 and was completed in September of 1981. Problems in personnel availability and scheduling delayed the collection of "Before" data until May and June of 1979. Improvements

were implemented starting in November 1979 and completed March 1980. Traffic performance "After" data were collected in May and June of 1980 (1 year's "After" accident data were accumulated from April 1980 to March 1981). A final report was submitted in July 1982. This report was not published, but is on file at the Office of Traffic Operations, FHWA.

Site Assessment ("Before")

The analysis of problems and the development of improvements was to be accomplished in accordance with the 1st Edition of the Users' Guide. However, time and scheduling constraints on the part of the New Jersey DOT led to the improvement development being accomplished, in part, using the "usual" New Jersey DOT procedures. The site assessment and accident analysis indicated driver confusion, attributed to the site's information system (actual "Before" performance data were collected post hoc). The route guidance conveyed by the in-place signing system was felt to be inaccurate and overloading, leading to driver confusion. Signals were too close together and many red light violations occurred. The circle was devoid of lane markings, further contributing to driver confusion. Accident experience at the site was deemed to be too high relative to similar locations.

Positive Guidance Plan

A number of changes were made to the site's signing, markings and signals. Continuous striping, including "elephant tracks," was added around the circle, and turning and straight through pavement arrows were added on lanes of the circle at the signals. The lane drop was

repositioned downstream in the eastbound lane, and a stop line was added for the fire station signal (see Figure 10). Traffic signal housings were painted yellow to enhance their detectability, and 12-inch signal heads replaced the existing 8-inch units on the first set of signals in the eastbound and westbound direction on SR 38. All signing on SR 38 was improved, as were the signs at the circle and on the side streets. Continuity of route guidance and destination signing was enhanced in accordance with the Positive Guidance analysis. Figures 11 and 12 show the "After" information on the SR 38 approach to the circle.

Project Evaluation ("After")

The MOE's used to evaluate the improvements were speed, speed variance, red light violations and accidents. Data were only collected on the SR 38 legs for the traffic performance MOE's, while accident data were compiled for all portions of the site. Mean speeds were reduced, both in the eastbound (-3.6 percent) and westbound (-1.7 percent) directions at the beginning of the circle. These reductions, while small in magnitude, were statistically significant. Speed variance, on the other hand, increased a significant 12 percent in the eastbound direction. Red phase signal violations increased in both the eastbound and westbound direction in five of the eight locations evaluated. Accidents, while reduced by 26 percent, were not statistically significant at the 95 percent level of confidence.

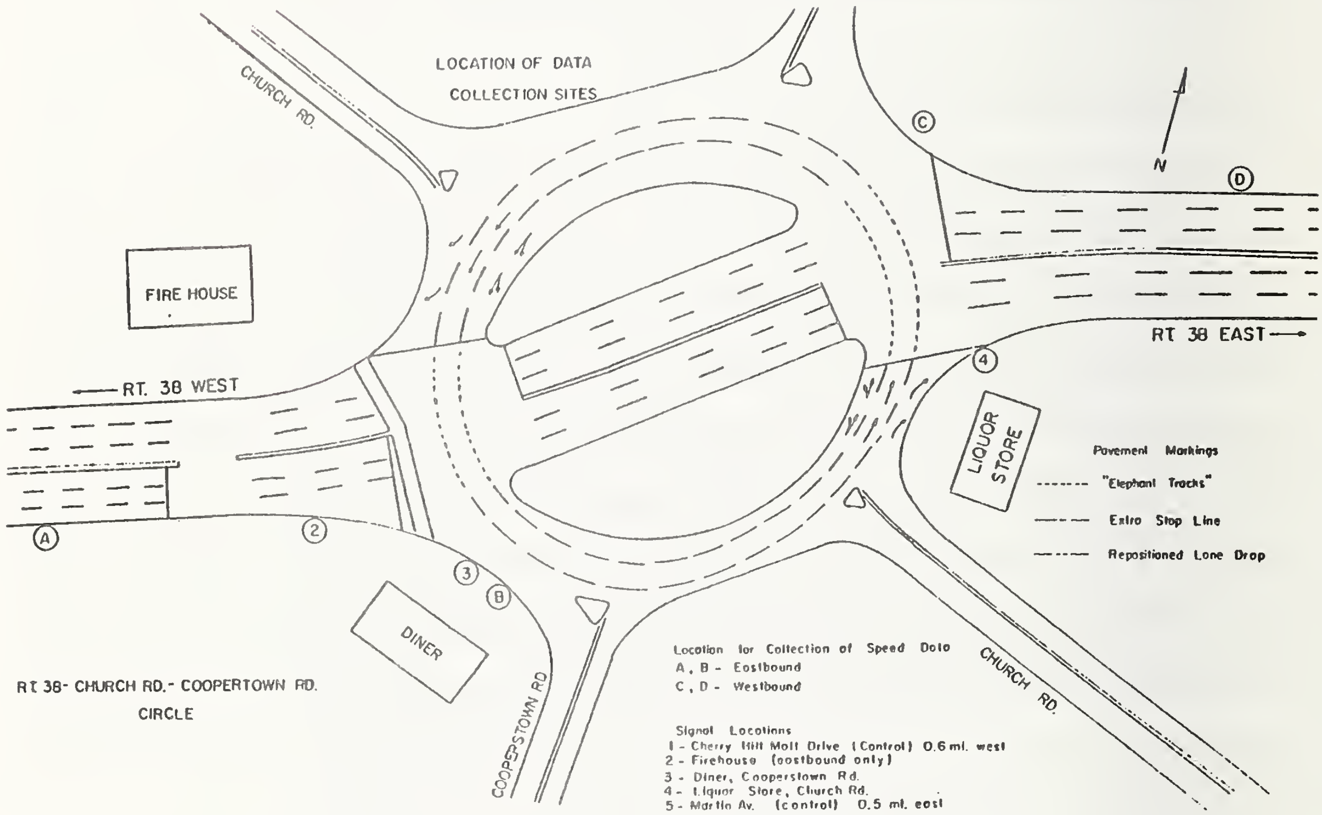


Figure 10. Marking Diagram and Signal Locations.

Figure 11. Navigational Information Approaching the Circle.

Figure 12. Navigational Information at the Circle.

Project Costs

Although $75,000 was allocated for this demonstration project, less than 1/2 was actually expended, as follows:

	Cost
. Traffic Engineering:	$ 10,932
. Research:	15, 584
. Maintenance:	2,653
. Supplies and Travel:	5,168
	$ 35,337

Conclusions

The staff who performed the engineering portion of the project did not feel that the Positive Guidance procedure was useful in improving as complicated a site as the cut-through traffic circle. They did, however, feel that Positive Guidance could be used as a training tool for new engineers since it "outlines in detail many of the steps experienced engineers follow automatically." The fact that the improvements generated by the procedure did not appear to improve the site's operations is somewhat born out by the performance data, although there were several methodological flaws in the improvement development and data collection phases which may have accounted for the project's lack of success. In addition, the lack of project manpower, coupled with the New Jersey DOT's design and evaluation structure, i.e., separate design activities for signs, signals and markings as well as a separate research organization to collect and analyze performance data, did not appear to be compatible with the 1st Edition version of Positive Guidance.

INTERCHANGE LANE DROP: CALIFORNIA

Project Description and History

On July 18, 1979, the California Department of Transportation, Division of Highways, contracted with the Demonstration Projects Division, FHWA, to design, implement, and evaluate a Positive Guidance analysis on a freeway site. After assessing two potential locations, a site on Interstate 5 in downtown San Diego at the southbound approach to eastbound State Route (SR) 95 was selected. The Positive Guidance study zone was a 4-lane roadway with a 5th lane striped as an auxiliary lane on a 10-foot shoulder. Southbound traffic in the 5th lane approached an on-ramp (5th Street) which merged on a separation structure for SR 163. The traffic continued downstream where it passed an off-ramp (Pershing Drive) and was trapped on a connector for SR 94. The 4th lane became an optional lane between I-5 and the SR 94 connector. A crest vertical curve began downstream of the 5th Street on-ramp, and a horizontal curve to the right began half way into the vertical curve which went beyond the gore point of the SR 94 connector. The total length of the site was ½ mile. The major areas of conflict were: The 5th Street on-ramp, where the ramp vehicles had a difficult time merging on to the freeway; the Pershing Drive off-ramp, where the ramp vehicles had difficulty weaving through lanes 4 and 5 because of vehicles from the 5th Street on-ramp and vehicles headed to the SR 94 connector; and, the gore area of SR 94 connector, where the 5th Street on-ramp mainline vehicles were being trapped off to the SR 94 connector, and other mainline vehicles were unable to merge to the 4th and 5th lanes for the SR 94 connector. The vertical and short radius horizontal curves made it difficult for

motorists to see the road ahead in sufficient time to maneuver to their desired destination. The site experienced 75 accidents, primarily sideswipes, rear enders, and single vehicle run-off-the-road types in the 4 years prior to project implementation. Traffic volume was high, with an ADT of 120,000.

The project was begun in July of 1979 and completed in October of 1983. "Before" data were collected in the summer and fall of 1979, the improvement implemented in early 1983, and "After" collected in the spring of 1983. A final report was delivered in October of 1983 (Reference 8).

Site Assessment ("Before")

The site was analyzed using the 1st Edition of the Users' Guide. It was determined that the site's problems could be attributed to the geometrics of the study zone, the lack of adequate sight distance, a lack of capacity at peak periods, and deficiencies in the existing information system. Sight distance problems were caused, in part, by blockage due to trees and shrubbery. While it was not possible to add additional capacity through reconstruction, a 6th lane could be added by stripping from the "5th Street" on-ramp to the "B Street" off-ramp (thereby creating a long weaving section). Signs and sign locations were found to be in improper places, not providing the correct information, nor giving adequate lane assignments. It was determined that a number of improvements addressing the above problems were needed, and that the complexity of designing an information system for the independent off-ramps, two of which have trap and optional lanes, within a 6/10-mile

distance, required a systematic design approach. A "standard" design plan could not be applied to the site.

Positive Guidance Plan

A number of changes were made at the site. These are shown in the plan presented in Figure 13. The 6th lane, between the "5th Street" on-ramp and the "B Street" off-ramp was added by striping. Lanes 1 through 5 were reduced in width from 12 feet to 11 feet, and the shoulder was reduced from 10 feet to 3 feet to accommodate this change. Standard ground mounted signing was added to reflect the change from a merge-diverge situation to an added lane on and a trap lane off. This restriping lengthened the weaving section discussed above, and increased the capacity of the facility. A ground mounted sign (not shown in Figure 13) for "B Street, and Pershing Drive" was relocated upstream because it was blocking sight distance to the exit gore and exit sign. This ground mounted sign should have been overhead. However, the project had to be downscoped to adhere to available funding. Another ground mounted sign, for SR 94 (not shown in Figure 13), was removed, again due to its blockage of sight distance. This increased the sight distance to the SR 94 gore area and signing. A number of changes, involving enhanced route guidance and lane assignment were made to the overhead guide signs, as shown in Figure 13. The revised signs provided a measure of consistency and continuity that was lacking in the "Before" information system, and added and/or corrected the lane assignment information presented to the driver. Advance warning of trapped lanes was enhanced, and panel size was increased for added emphasis. Finally, sight distance was improved by trimming palm trees that were restricting

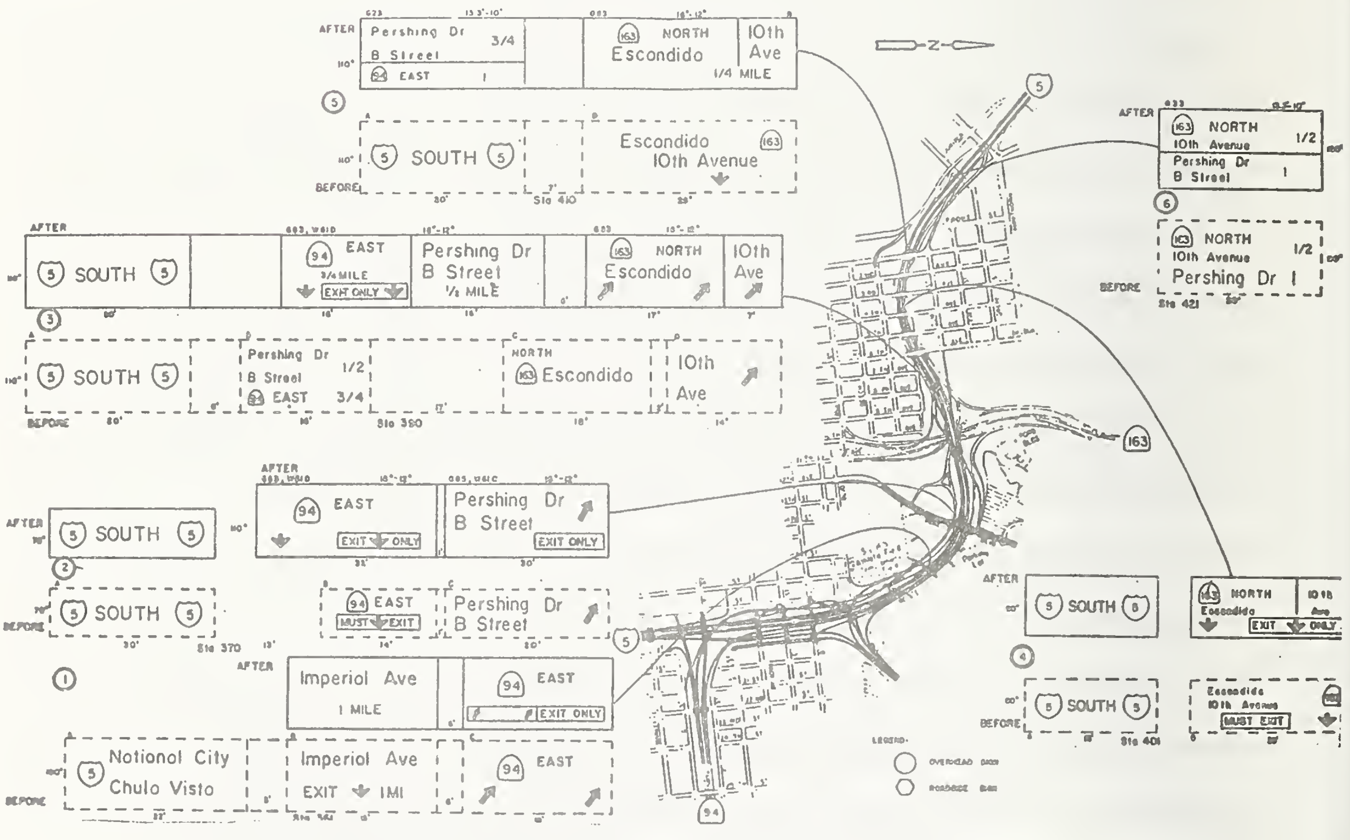


Figure 13. Positive Guidance Plan.

vision. Figure 14 shows the Positive Guidance information display at the lane drop. The Positive Guidance plan increased capacity, improved sight distance, and improved driver path and destination information.

Figure 14. Signing Treatment at Lane Drop.

Project Evaluation ("After")

The measures of effectiveness (MOE's) used to evaluate the improvements were lane usage, lane changes, and erratic maneuvers. "Before" and "After" data were collected during the weekday peak (pm) and off-peak, and during the weekend peak (pm) to reflect commuter and non-repeat driver behavior. Data were collected photographically using two time-lapsed film cameras mounted on a suitable overpass. This enabled data to be gathered upstream and downstream. A comparison of "Before" and "After" lane usage, measured as traffic volume, showed an increase

in weekday off-peak traffic greater than for other area freeways, indicating that additional traffic may have been attracted to I-5 when the difficult and unsafe merge was removed at the "5th Street" ramp. In addition, the heavy "Before" volume in the number 4 lane was found to have been distributed into the other lanes, allowing for additional traffic and weaving. Significant reductions in lane changes were noted during weekday peak periods as well as weekend peak periods. A significant decrease in lane changes occurred in an area where lane changes were not desirable, thus pointing to improved traffic operations. Finally, there was a significant decrease in erratic maneuvers during the weekend period, when the target population of non local drivers is apt to be maximized. There was, however, an indication that the overhead sign that could not be provided due to funding limitations was needed. Motorists were trapped in the 5th Street lane. This was determined through an increase in erratic maneuvers at the SR 94 connector. There were insufficient data to perform a "Before"/"After" comparison of accidents at the site.

Project Costs

The total cost, including $15,500 in engineering for an untreated site, was $120,500, thereby exceeding the $100,000 allocated for the project. The cost breakdown was as follows:

Pre-Construction	$ 35,500
Construction	$ 65,500
Construction Engineering	$ 11,100

After Construction	$ 8,900

The State of California made up the short-fall in funding from its Safety funds.

Conclusions

The State of California concluded that the project and the Positive Guidance procedure were worthwhile. Although project personnel initially felt that the Positive Guidance procedure was redundant, after the project was completed and the process reviewed, the conclusion was that the process was not redundant and that each function was necessary. The final report stated:

> "We feel that the Positive Guidance procedure is a very valid procedure, which takes away some of the "seat of the pants" engineering and puts it on a scientific basis. We realize that the procedure was written so that any traffic engineer could pick it up and use it with very little guidance, but we feel that a team or teams of specialists, either at the State or Federal level, would be a more practical approach. This procedure should be used as a training tool for traffic engineers, either as a rotation through a specialist team or as a hypothetical project to be done by rotatees through traffic operations."

RAILROAD-HIGHWAY AT-GRADE CROSSING: GEORGIA

Project Description and History

On August 28, 1979, the State of Georgia, Department of Transportation, contracted with the Demonstration Projects Division, FHWA, to plan, design, implement, and evaluate a Positive Guidance analysis of a railroad-highway at-grade crossing, number 340403B, located in Cobb County, Georgia. The conduct of the Positive Guidance analysis was sub-contracted to the Georgia Institute of Technology (Georgia Tech), School of Engineering. The site was located north of Marietta, Georgia, and the Kennesaw Mountain National Battlefield Park in Kennesaw, Georgia. The crossing was located on Stanley Road, an 18-foot wide, rural two-lane east-west local road on the Federal-Aid Secondary (FAS) system. Stanley Road crossed a single track of the L&N Railroad. A "dead end" side road, Line Road, paralleled the track and led to a boarding school. There were sight distance restrictions in each direction. The crossing's information system consisted of a "Stop Ahead" sign in the westbound direction, two Stop signs, and a wooden "Crossbuck." An obsolete "Georgia State Law, Unsafe RR Crossing" sign was also present. One accident occurred at the site in the 3 years prior to project implementation. The crossing experienced 37 train movements per day, some at unpredictable times. Train speeds ranged from 5 to 30 mph. Stanley Road had an ADT of 1,100 vehicles per day, most of whom were "locals." The Georgia DOT calculated the hazard index (Peabody-Dimmick formula) for the site at 8.38. This was considered to be high for this type of crossing.

Work did not begin on the project until Georgia Tech was subcontracted in December of 1979. The project was implemented in levels. Level 1 represented the site before any work was started. The second level brought the site into compliance with the Manual on Uniform Traffic Control Devices (MUTCD). During the third level, Positive Guidance was applied and a passive Positive Guidance improvement developed. A final level, beyond the scope of the demonstration project, was to apply active ("Gates, Lights, Bells") devices at the site. Level 1 ("Before") data were collected in January and February of 1980. Level 2 improvements were implemented after data collection, and were in-place by March of 1980. Level 2 data (1st "After") were collected in April and May of 1980. Level 3 (Positive Guidance-passive) improvements were implemented by September of 1980 and Level 3 (2nd "After") data were collected in October and November of 1980. A final report was submitted in June of 1982. This report was not published, but is on file at the Office of Traffic Operations. The project results were reported at the 1982 Annual Meeting of the Transportation Research Board (Reference 9).

Site Assessment

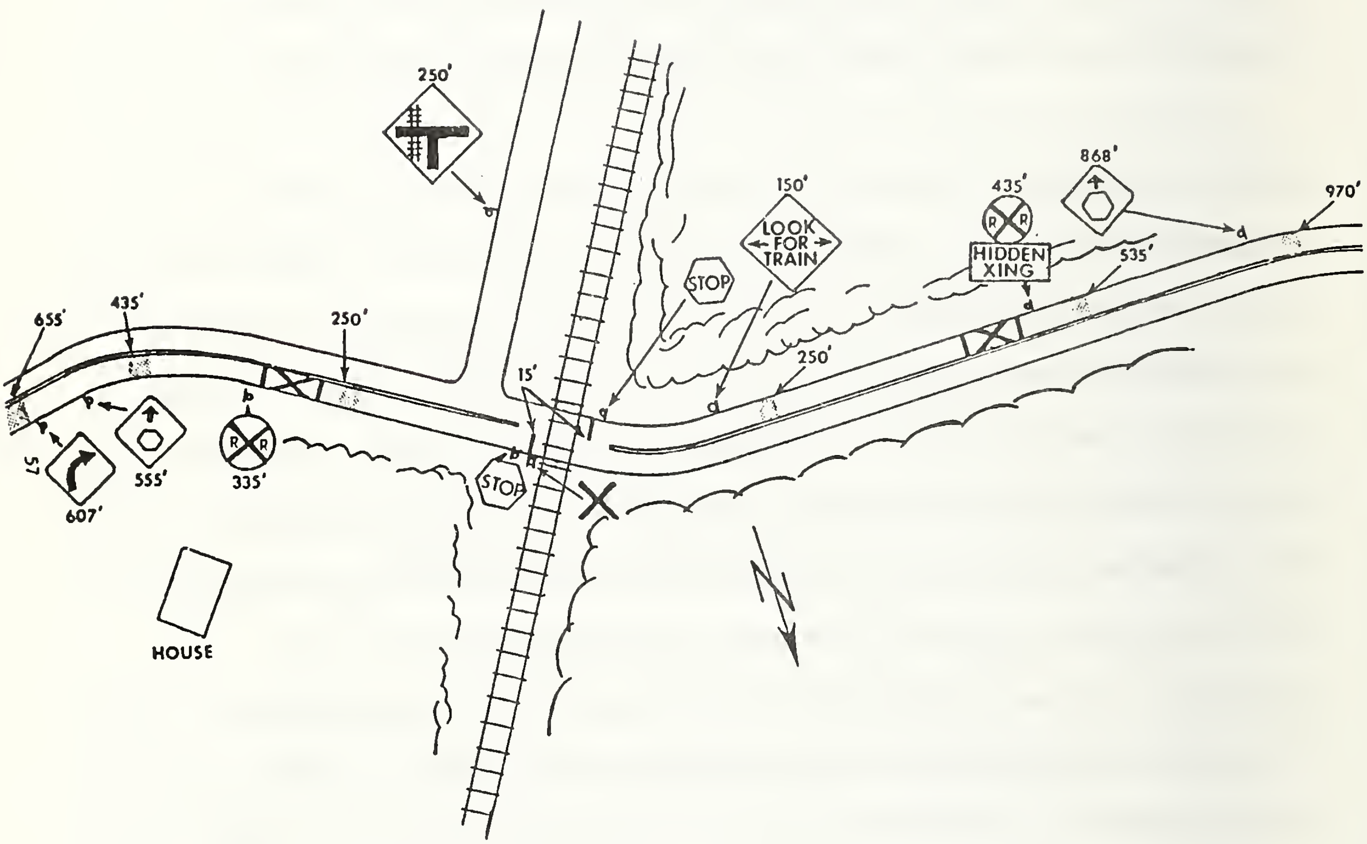
Level 1 - "Before": The site was assessed using the 1st Edition of the Users' Guide. Before any improvements were made, the site had very poor sight distance in both the west and eastbound directions due to fences, trees, and hillocks in all four quadrants. The in-place traffic control devices were insufficient to warn motorists of the existence of the crossing, and were either obsolete (e.g. Georgia Unsafe RR Crossing sign) or inadequate (e.g. stop lines were missing at the crossing, even though a Stop sign was present in each direction), particularly given

the large number of train movements and unpredictable arrivals. Observations showed a large fraction of the motorists ignored the Stop sign and slowed down no more than necessary to negotiate the crossing, that is, to speeds between 20 and 25 mph, and appeared to rely entirely on approaching train horns as a warning that a train was arriving. Those who stopped did so too close to the train track. The site was judged by project staff as typifying the classic problem of the inattentive local driver that lacks respect for the site's hazards.

Level 2 - "Before": The site's information system was upgraded to minimum MUTCD standards (Reference 10) with the addition of Stop Lines (W2-1), advanced "RR XING" and "Stop Ahead" signs (W3-1a), and advance RR pavement markings (Figure 8-2 and Para. 8B-4, MUTCD). After a 30-day acclimation period, the MOE's collected during Level 1 were again taken. Head turning movements and stopping behavior were collected manually, while speed and speed profile were collected automatically using radar and tape switches inputting into an in-field computer based speed classifier. It was concluded that the minimum MUTCD treatment was inadequate, based on the Site Survey and Operations Review, looking and stopping behavior, and a speed profile. Performance MOE's did not show a change from Level 1 to Level 2.

Positive Guidance Plan (Level 3): A passive plan, developed on the basis of an analysis of the site, using the Level 2 treatment as a base line, is shown in Figure 15. Since the eastbound approach offered a very poor view of the track, a "Look for Trains" sign was added, and a

Figure 15. Positive Guidance Plan. Shaded Areas are Rumble Strips.



similar message was installed below the existing Advance RR XING sign. Rumble strips were added on each approach, to provide an additional tactile and auditory alert. Figure 16 shows the site in the eastbound direction. A diagrammatic left-turn RR XING sign was added on the access road next to the track. It was originally planned that this project would also test-out "innovative" techniques such as HAR (Highway Advisory Radio) and changeable message signs in the next level. However, since analysis showed that Stanley Road was used almost exclusively by locals, it was felt that these drivers would not tune in to HAR or pay attention to other innovative devices. Thus, this phase of the demonstration project was not implemented.

Figure 16. Eastbound View of Site.

Project Evaluation (Level 3 - "After")

The MOE's collected during Level 2 were also used in the Level 3 project evaluation phase. Data were analyzed using the procedures contained in the Evaluation of Traffic Operations, Safety and Positive Guidance Projects report. Surprisingly, "looking" behavior, which improved between Levels 1 and 2, showed a worsening after Level 3. However, the percentage of vehicles not stopping decreased after the installation of the Positive Guidance improvement, and the location of stops in the westbound direction showed an improvement. There was no significant improvement in speed profile in any of the Levels evaluated. An unexpected observation was that approximately 6 drivers per day were found to cross the centerline to avoid the rumble strips. Evaluation results were suspect because: (1) Stanley Road was used almost exclusively by locals; (2) the railroad improved the track surface and geometry (not part of the Positive Guidance improvement) thereby increasing speeds in the vicinity of the track (this change was accomplished without the coordination or approval of the Georgia DOT) (3) changes occurred in data collection personnel; and (4) operational definitions for a "Stop" changed between Levels 2 and 3.

Project Cost

The final cost of the project was $60,000, primarily to subcontract to Georgia Tech. Georgia Tech's contract was valued at $53,420. The remaining costs were for materials and travel.

Conclusions

The Georgia DOT concluded that having a university perform the data collection and analysis resulted in a project that was performed in a shorter and more efficient manner than the State would be able to do. The fact that the project was delivered below $100,000 was attributed to Georgia Tech's efficiency in implementing the study and the Georgia DOT's inexperience in estimating projects of this type. In all, the State of Georgia was satisfied with the conduct of the project.

Georgia Tech, as a research oriented university, had no trouble applying the Positive Guidance process. However, they felt that it could be complicated for some traffic engineers to applying at simple sites. They indicated that the procedure would assure that drivers were not overloaded at a complex site. They stated:

> "Agencies plagued with lawsuits should find the time spent documenting the Positive Guidance procedure would pay for itself many times over in reduced liability."

They recognized that the methodological problems in using different student observers and observational techniques may have led to the conflicting project results. Finally, they concluded that the fact that the road was used almost exclusively by "locals" resulted in a situation where it would not be possible to change driver behavior with any passive treatment, and that the "gates, lights and bells" that the Georgia DOT will install at this site would be more effective.

URBAN INTERSECTION: DUBUQUE, IOWA

Project Description and History

On April 15, 1980, the Iowa Department of Transportation contracted with the Demonstration Projects Division, FHWA, to plan, design, implement, and evaluate a Positive Guidance analysis of an urban intersection in the city of Dubuque, Iowa. An agreement with the city of Dubuque was subsequently signed whereby the city would perform the design and data collection tasks, and the city and State would jointly perform the evaluation and reporting functions.

The site, shown in Figure 17, was the intersection of Dodge Street with Bluff and Locust Streets (including all approaches), located in Dubuque's central business district. Bluff Street was one-way southbound into Dodge Street, and Locust Street was one-way northbound from Dodge Street. The intersection of Dodge Street eastbound with Bluff Street southbound was a "dog leg" T, followed by a standard 4-way intersection at Locust and Dodge Streets. All legs of the Bluff Street-Locust Street one-way pair operated as a single unit. The site was the intersection of Iowa State Route (SR) 3, U.S. 20, U.S. 52, U.S. 61, and U.S. 151. The east leg of the junction was a two-lane bridge across the Mississippi into Illinois. The west and south legs of the intersection were both two-way, 4-lane arterials. Almost all traffic entering Dubuque passed through this intersection. The land-use was commercial strip development with residential homes. Operational problems caused severe congestion at peak periods, with traffic occasionally backed up over a mile on each approach. Horizontal

curvature restricted sight distance in the north, east and south approaches. Vertical grades were a problem during inclement weather. Traffic volume was moderate-to-heavy, with an ADT of 22,000 (9 percent trucks). In the 3-year period prior to project implementation, there were 74 accidents on Dodge Street at Locust Street, and 45 accidents on Dodge Street at Bluff Street.

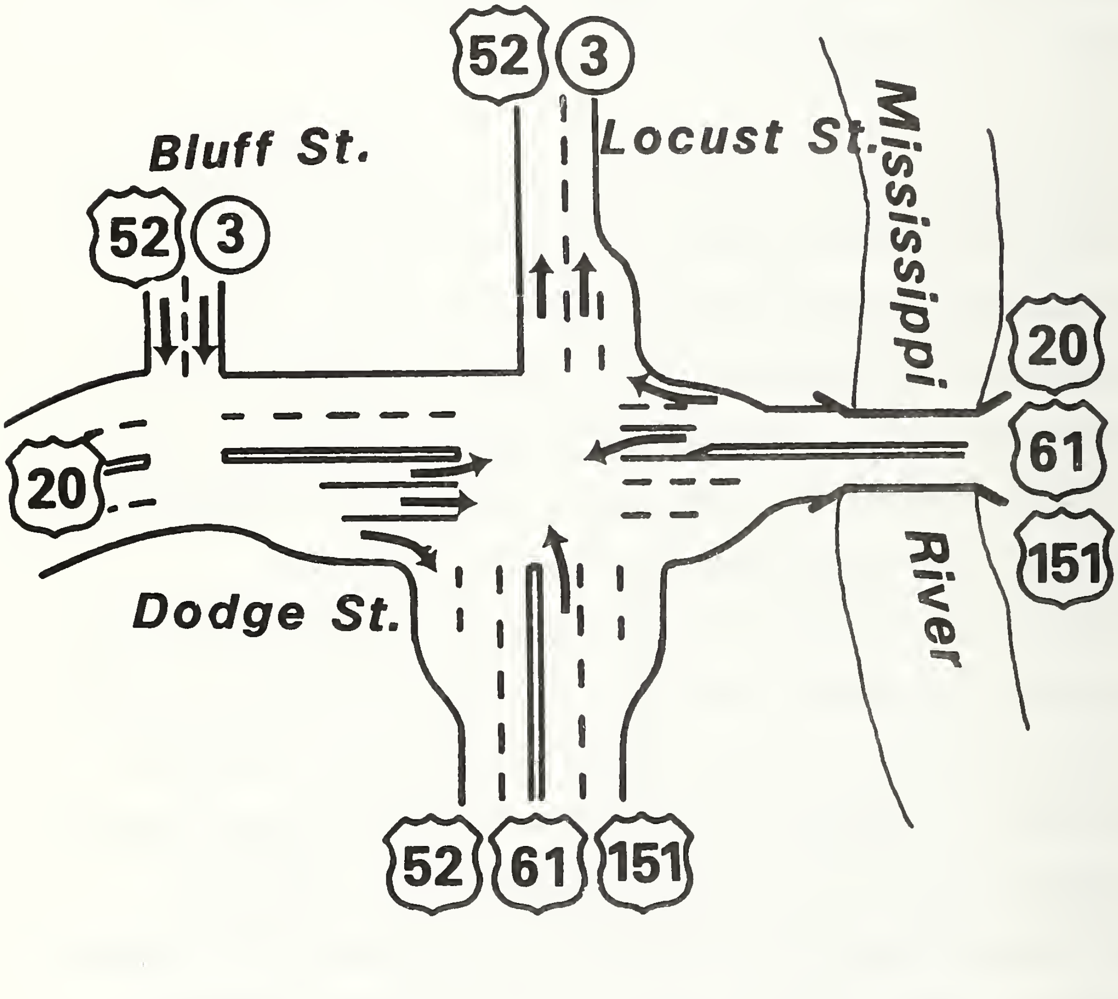


Figure 17. Intersection Configuration.

The project was started in June of 1980 and completed in September of 1983. "Before" data were collected in the fall of 1980. The improvement implementation was delayed until the summer of 1982, necessitating a 2-stage improvement implementation and evaluation. The 2-stage project was caused by the accelerated opening of a new Dubuque to Wisconsin bridge. Stage 1 consisted of interim signing, geometric changes, and new pavement markings. Stage 2 included new signing to show route changes to the new bridge, and new signals. Stage 1 data were compared to "Before" data to evaluate the improvements. This yielded a 15-day acclimation period which, although somewhat inadequate, was deemed to be the best compromise, given the accelerated bridge opening. Stage 1 ("After") data were collected in August of 1982. A final report was submitted in September of 1983 (Reference 8).

Site Assessment ("Before")

The 1st Edition of the Users' Guide was used to assess the site. The site was surveyed, historical data were reviewed, and data collected using time lapse photography (Note: "After" data were collected manually due to equipment malfunctions). The site assessment was broken down into the following components:

o Dodge Street (U.S. 20)Eastbound: As Dubuque's major east-west arterial, Dodge Street was heavily traveled, with considerable truck traffic, a large volume of tourist traffic, and much congestion. Route guidance was inadequate and difficult to follow, particularly in Dodge Street's cluttered visual environment and poor sight distance. Existing signs were poorly illuminated, difficult to read at a distance,

and contained too much information at a location too late to properly respond. Traffic signals were hard to see.

- Locust Street (U.S. 52, U.S. 61, U.S. 151) Northbound: Traffic congestion problems occurred in a similar fashion to those on Dodge Street. Route guidance information was minimal, signs were poorly placed in a cluttered visual environment that competed with navigational information, and signals were poorly placed and difficult to see.

- Bluff Street (U.S. 51, SR 3) Eastbound: Bluff Street experienced congestion and back-up during peak periods. Route signs were small, difficult to detect, and too complex.

- Dodge Street (U.S. 61, U.S. 20, U.S. 151) Westbound: Dodge Street westbound was the two-lane approach coming off the existing Mississippi River bridge. Traffic was evenly distributed throughout the day, with weekend back-ups during the tourist season. Signing along the bridge was adequate, although the area approaching the intersection was somewhat visually cluttered.

- Dodge, Bluff, Locust Streets Intersection: The offset arrangement of the intersection caused congestion and confusion to motorists attempting to negotiate a proper course. The number of intersecting routes complicated the task of presenting navigational information. Traffic signal visibility and phasing was inadequate, and delineation needed improvement. Numerous traffic conflicts and erratic maneuvers were observed, and considerable delay was found. The

Locust Street and Dodge Street approach experienced a wide range of approach speeds. Eighty-fifth (85th) percentile speeds on all approaches exceeded the posted limit.

Positive Guidance Plan

The Positive Guidance plan included changes in channelization, new traffic signals, hazard markers, and route guidance signs. Route guidance information was implemented in two stages to accommodate the new Dubuque to Wisconsin bridge. Traffic signal improvements were delayed until 2 months after Stage 2 changes and were consequently never evaluated. Figure 18 shows the Positive Guidance plan for navigational information. The following are features of the plan:

- Dodge Street Eastbound: An enhanced routing sign was installed in the approach to Locust Street, and verification and final decision point confirmation was displayed at the intersection. Supplemental pavement markings were used for clear lane requirements. Together, the signing and markings established driver commitment and early routing identification. Signal heads over travel lanes led to quicker response. A mountable raised median barrier discouraged left turns thereby reducing midblock traffic conflicts. Finally, islands and medians provided channelization to reduce erratic maneuvers. Figure 19 shows the eastbound approach.

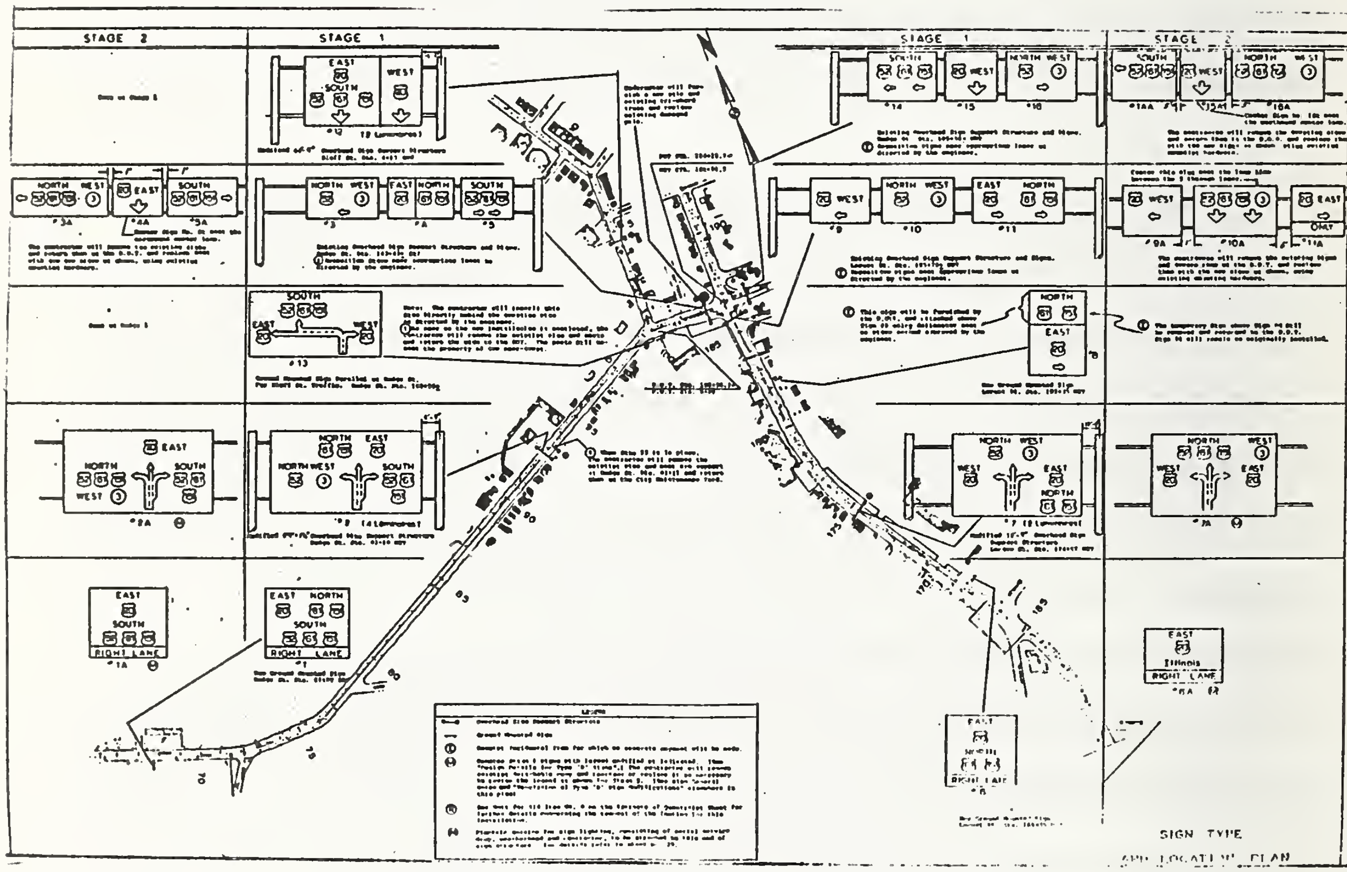


Figure 18. Positive Guidance Plan.

Figure 19. Dodge Street Eastbound.

o Locust Street Northbound: An overhead diagrammatic sign displayed routing through the intersection. The existing right turn lane was extended and a road-mounted sign added to provide a "Right Turn Only" message. Overhead signs at the intersection were modified for increased visibility and lane assignment verification. Navigational information was supplemented by lane directional markings. Raised islands and center medians channelized traffic and reduced erratic maneuvers. Signal heads over traffic lanes provided increased visibility. Figure 20 shows the northbound approach.

Figure 20. Locust Street Northbound.

o Bluff Street Southbound: An advance roadside route marker displayed lane placement, confirmed at the intersection by a ground-mounted diagrammatic. Advance supplemental markings indicating mandatory turns for each lane yielded proper lane selection. Pedestal mounted signals were placed in the line-of-sight of the diagrammatic. Figure 21 shows the southbound approach.

Figure 21. Bluff Street Southbound.

o Dodge Street Westbound: Route designation signs were realigned at the intersection, and traffic signals upgraded. A left-turn bay allowed for an additional through-traffic lane and allowed opposing left turn lanes to line-up. Raised medians and new markings delineated and channelized traffic through the intersection. Figure 22 shows the westbound approach.

Figure 22. Dodge Street Westbound.

Project Evaluation ("After")

The measures of effectiveness used to evaluate the improvements included volume, critical lane use, intersection delay (average and stop time), percent stopping, approach speed, traffic conflicts, and erratic maneuvers. It was beyond the time-frame of this project to analyze accidents.

The evaluation was flawed by a number of problems including a lack of comparability due to the bridge opening, an inadequate acclimation period, different "Before" and "After" data collection methods, personnel changes, and signal improvements not in place. This resulted in a more subjective assessment with reliance on public acceptance and engineering judgment. Performance data between the "Before" and Stage 1 "After" phase yielded the following: (1) Traffic volume remained constant; (2) peaking conditions increased due to the new bridge; (3) the accommodation of additional traffic through restriping and channelization improved the level-of-service; (4) delay was decreased on the eastbound and westbound approaches of Dodge at Locust, with an overall balanced improvement and equalization of delay per stopped vehicle and a reduction in the percentage of vehicles stopped on each approach; (5) traffic conflicts were significantly decreased at Dodge and Bluff Street, eastbound and westbound, and Locust and Dodge Street, northbound.

Project Costs

The total cost of the project was $223,000. Twenty-three thousand dollars ($23,000)) was for engineering, the remainder for improvements and construction. The State of Iowa provided the support structures for the overhead guide signs on Dodge Street and made up the short-fall from the allocated $200,000 with its Primary funds. The city of Dubuque did not charge for the salary of the project engineer.

Conclusions

In spite of its problems, public acceptance of the project was high, many of the performance MOE's showed improvement, and the staff's engineering judgment was that the intersection's operations improved. With regard to the use of Positive Guidance in assessing an urban problem, the project engineer felt that time constraints of local government would make it advisable to keep studies and reporting requirements to a minimum. It was concluded:

> ". . . the procedure provides a logical and clearly thought out methodology for problem analysis. The experience of the individual doing the study will, over time, allow for individual modifications to fit local needs. Continued development of the Positive Guidance procedure has helped to reduce study redundancy and provided a basis for local use."

REVERSE CURVES ON A RURAL TWO-LANE ROAD: WASHINGTON

Project Description and History

On December 9, 1981, the existing contract with the Washington State Department of Transportation was modified to include an additional site in District 4. A major purpose for adding this additional project was to apply the new Positive Guidance procedure contained in the 2nd Edition of the Users' Guide.

The site was located between M.P. 46.51 and M.P. 47.29 on State Route 14 in Skamania County, approximately 47 miles east of Vancouver, Washington. State Route 14 followed the Columbia River which cut through the Cascade Range at the site's location. The roadway was a two-way, two-lane road with 11-foot lanes and a variable shoulder adjacent to a bluff and a drainage ditch in the westbound direction. The site contained 7 horizontal curves (referred to as "Sweeney's Curves"). From January 1979 to December 1981, there were 22 accidents, including 1 fatality. Most accidents occurred in the westbound direction at curves no. 4 and 5. The site had moderate volume (5,100 ADT) and was rural and mountainous in nature.

The project began in January of 1982 and ended in November of 1983. Positive Guidance was applied in both the eastbound and westbound direction, with major emphasis placed in the westbound direction. "Before" data were collected in the spring and summer of 1982. The Positive Guidance improvements were implemented in October of 1982, and "After" data were collected in the fall of 1983. A final report was

submitted in March of 1982 (Reference 8).

Site Assessment ("Before")

A draft copy of Planning and Field Data Collection was supplied for use in collecting traffic and driver performance ("Before") data. Part II of the 2nd Edition of the Users' Guide, "The Engineering and Human Factors Procedure," was used to analyze the data, assess the site's operations, and develop the Positive Guidance Plan. It was determined that the existing information system (Figure 23) did not adequately address the variety and number of horizontal curves through the site. Speeds were too high. In addition, there were inadequate recovery areas, particularly in the westbound direction at curve 5. Most of the crashes at occurred at that location, and most involved single vehicle run-off-the-road accidents due to improper speed and path.

Positive Guidance Plan

Figure 24 shows the Positive Guidance Plan generated in Step 11 of the Engineering and Human Factors Procedure. The plan featured the use of standard warning devices to emphasize curve no. 4 and 5 for westbound traffic, and Chevron Alignment signs with advisory speed plates to supplement the advance curve warning. A ditch on the right side of the road was backfilled and paved to provide a recovery area between the roadway and the rocky bluffs, and concrete "safety shapes" were added for additional protection. Path delineation was enhanced with reflectorized raised pavement markers (RPM's), new edge lines, and double yellow centerlines. Figure 25 shows the site in the westbound direction.

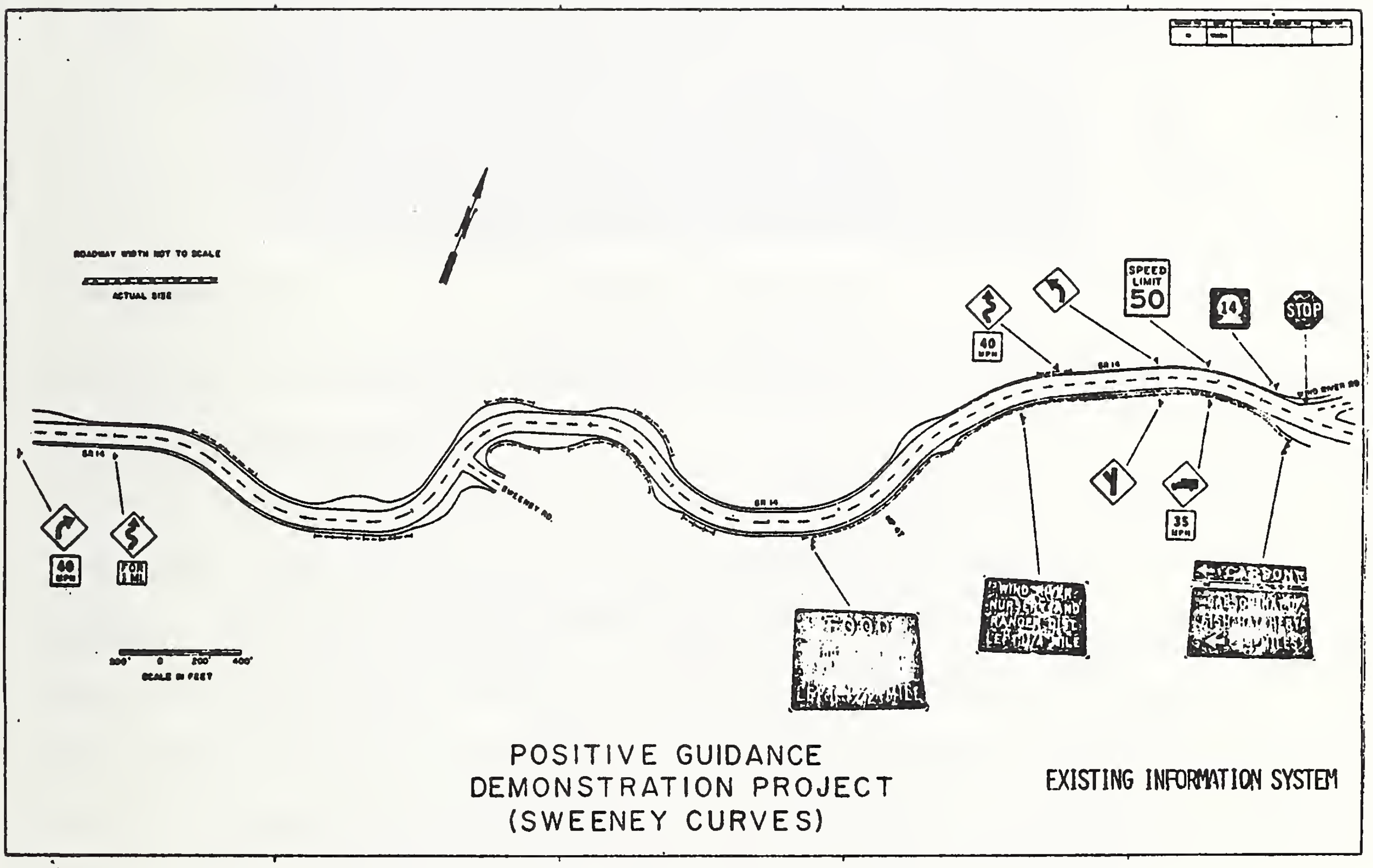


Figure 23. Existing (Before) Information System.

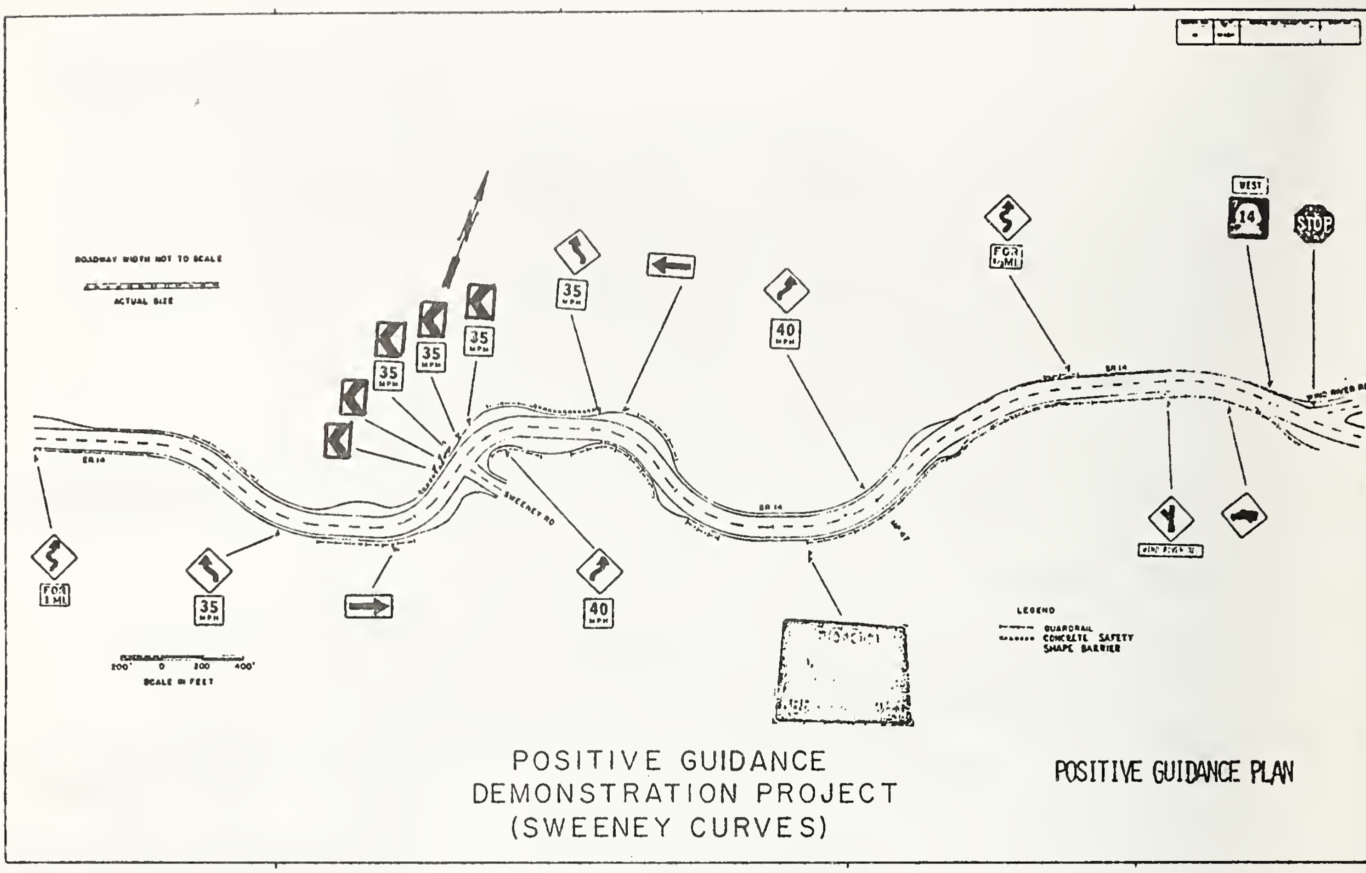


Figure 24. Positive Guidance Plan.

Figure 25. Sweeney Curve Westbound.

Project Evaluation ("After")

This project was evaluated in accordance with the procedure of Evaluation of Traffic Operations, Safety, and Positive Guidance Projects. The 1-year Implementation and Acclimation time period between "Before" and "After" data collection was necessitated by the loss of the RPM's during the winter snow plowing season of 1983. Project personnel felt that a 6-month period would have been sufficient for this project. Depressed RPM's were substituted, and additional acclimation time was provided. Two MOE's were considered, accidents and speed. It was expected that the improvements would reduce accidents and lower speed entering curve no. 4 and 5. A comparison of "Before" and "After" data yielded statistically significant reductions in both MOE's. However,

whereas accidents were reduced a substantial 88.4 percent, speed reductions were a modest 1 mph (at the 85th percentile speed). It was felt that this lowering of speeds was not practically significant. What was practically significant was the path improvement brought about by the information system improvements and the addition of the recovery area. In fact, this path improvement may have mitigated any speed reduction.

Project Costs

Forty-three thousand dollars ($43,000) was spent for the project. This included all costs for material and labor.

Conclusions

The redundancy in the various Positive Guidance Functions and steps noted by the project staff in the implementation of the "Pluvious Westerly" project were not found in the conduct of this follow-on project. Thus, the streamlining of the Positive Guidance procedure between the 1st and 2nd Edition versions of the Users' Guide to Positive Guidance achieved its goal. An additional conclusion reached by the project staff was that the procedure "must be applied without prejudging solutions for its application to be fully successful." In all, the project staff, the FHWA contract manager, and the motoring public using the road at the "Sweeney's Curves" location all agreed that the project was highly successful.

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